AIR QUALITY ASSESSMENT
THUNDER BAY TERMINALS LIMITED
THUNDER BAY

1979

D. J. Racette
Plant Pathologist

H. D. Griffin
Chief, Air Quality Assessment

TECHNICAL SUPPORT SECTION
NORTHWESTERN REGION
ONTARIO MINISTRY OF THE ENVIRONMENT

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SUMMARY

Since 1975, the Ontario Ministry of the Environment has undertaken pre- and post-operational air quality investigations in the vicinity of a coal storage and trans-shipment facility operated by Thunder Bay Terminals Limited in Thunder Bay. The first trainload of coal arrived at the project site in June, 1978. Studies by the Ministry in 1979 included vegetation and soil sampling, a moss exposure experiment, snow sampling, and measurements of dustfall and suspended particulate matter.

There was no evidence of air pollution damage to vegetation in the study area. Levels of aluminum, arsenic, iron and mercury in vegetation foliage near the coal piles showed no significant change in 1979 compared with data from a pre-operational survey in 1975. Similarly, there was no indication of soil contamination.

Aluminum, arsenic, calcium and iron were slightly elevated in moss exposed near the coal storage area, but mercury concentrations were normal. Aluminum, carbon and iron were also well above background levels in snow in the same location, but arsenic, calcium, mercury, sodium and sulphate concentrations were acceptable. The elevated values in moss and snow were restricted to the immediate vicinity of the coal piles and did not extend off the project site.

Dustfall and suspended particulate measurements showed that dust concentrations on Thunder Bay Terminals property and in adjacent areas did not change significantly following commencement of company operations in mid-1978. All data indicate that there are no significant dust emissions from Thunder Bay Terminals to the present time.

INTRODUCTION

In 1975, the Ontario Ministry of the Environment began pre-operational air and water quality studies around a site designated for a coal terminal on McKellar Island, Thunder Bay harbour. This facility, operated by Thunder Bay Terminals Limited, received its first trainload of coal from western Canada in June, 1978.

Air quality monitoring results from 1975 to 1978 were presented in earlier reports (1, 2, 3, 4, 5). These studies showed that dust levels around the project site and the adjacent residential areas remained essentially unchanged after coal shipments began. Dust concentrations usually complied with Ontario's air quality objectives at all sampling locations. Levels of several elements in local vegetation and soil were also found to be normal.

Dustfall measurements, moss exposure experiments and snow sampling surveys also revealed that particulate matter emitted from two other industrial sources (a thermal generating station and a bulk storage facility) within 3 kilometres of Thunder Bay Terminals were responsible for localized dust deposition near the sources concerned.

In 1979, the first complete post-operational air quality investigations were carried out, with studies on contaminant levels in vegetation, soil, moss and snow, and measurements of airborne dust concentrations.

VEGETATION AND SOIL SAMPLING

VEGETATION

On July 11, indigenous vegetation was examined for evidence of air pollution injury, insect attack and disease problems. Except for trees and shrubs in a small area northwest of Valley Camp Limited, where sulphur dioxide injury had occurred following

a sulphur fire on July 9, all plant life was free of visible damage attributable to air pollutants. A minor level of injury was caused by insect defoliators on trembling aspen, and a severe infestation by ugly nest caterpillars (Archips cerasivoranus) was noted on speckled alder (Alnus rugosa) shrubs in the same area.

Foliage was collected from trembling aspen (Populus tremuloides) or balsam poplar (Populus balsamifera) trees at 16 sites near Thunder Bay Terminals (Figure 1) and from two control locations remote from the study area. Triplicate samples, each comprising about 500 g (grams) fresh weight, were obtained by trimming outside leaf growth to a height of about 3 m (metres) above ground level on the sides of trees facing the source under investigation. The collected leaves were placed in perforated polyethylene bags and stored under refrigeration ($4^{o}C$) until processed in the Ministry's Laboratory facilities in Thunder Bay. Samples were then dried in an oven at $80^{o}C$ for 30 hours, and ground in a Wiley mill equipped with a 1-mm (millimetre) pore-size screen. Samples for aluminum and iron analysis were subsequently subjected to ashing and acid digestion, after which aluminum and iron were determined by atomic absorption spectrophotometry. For arsenic determinations, sample material was digested in an acid mixture at low heat, followed by analysis with flameless atomic absorption spectrophotometry. Mercury was determined by ultraviolet atomic absorption spectrophotometry.

Chemical analysis results for vegetation samples are summarized in Table 1. Levels of iron were slightly elevated in the vicinity of the coal piles at Thunder Bay Terminals Limited. Similar concentrations were found at sites closest to Valley Camp Limited and at a location (station 12) near Ontario Hydro's fly ash disposal area. There was little evidence of aluminum, arsenic and mercury contamination in foliage, although aluminum levels in the study area were a little higher than those at the control sites. The unusually high aluminum and iron concentrations in the balsam poplar control sample were attributed to road dust contamination. A slight increase in

aluminum and iron levels in trembling aspen foliage was recorded at stations 6, 18 and 22 in comparison to concentrations found at the same locations in a 1975 pre-operational survey, but this increase was not considered significant.

SOIL

Soil was collected on May 22-23 with a stainless steel corer, 2.5 cm in outside diameter, from one depth (0-10 cm) at 18 stations in the study area (Figure 1), and at two distant control sites. Surface debris and loose organic matter were removed from the ground surface before each insertion of the corer. At least 10 cores of soil were pooled to form one sample. Triplicate samples were obtained from each site and were placed in polyethylene bags for storage pending analysis. At the Ministry's Thunder Bay Laboratory, the collected material was spread on paper and air-dried for 48 hours, coarse screened to remove stones and plant material, then fine screened through an 80-mesh sieve. Processed soil was digested in mixed acids at low temperatures and analyzed for arsenic and mercury by the same methods specified for vegetation.

Soil analysis results are presented in Table 2. The highest arsenic level, at station 15, slightly exceeded the upper limit of normal background concentration (25 µg/g) expected in Ontario surface soils (0-5 cm). Arsenic was low in all other samples, and there was no trend of decreasing arsenic levels with increasing distance from the coal piles. There was also no evidence of mercury contamination in soils, and all mercury values fell within the range considered normal. Compared with 1975, arsenic concentrations showed some fluctuation, with decreases actually outnumbering increases. However, none of these changes were considered significant.

MOSS BAG EXPOSURE

Mosses are effective substrates for absorbing and retaining some types of airborne contaminants. Techniques have been developed to suspend small quantities of moss in open-mesh bags to monitor the atmospheric environment (6). At Thunder Bay Terminals Limited, bags of Sphagnum moss were exposed from May 22 to July 10, 1979, at 18 sites (Figure 1) plus two control locations remote from the survey area. Each sample comprised about 4 g of oven-dried moss contained in a 10 by 20 cm envelope of polypropylene screening attached to a plastic supporting bracket about 2.5 m above ground level. Samples, after exposure, were placed in polyethylene bags for refrigerated storage ($4^{o}C$) until processed at the Ministry's Thunder Bay Laboratory.

The analytical results are presented in Table 3 for 19 of the original 20 samples. One sample was lost during the exposure period. Slightly elevated concentrations of aluminum, arsenic, calcium and iron were present in moss exposed at sites closest to the Thunder Bay Terminals coal piles. The distribution pattern for iron, plotted in Figure 2, was generally similar to that for aluminum, arsenic, and calcium. The slightly elevated levels of arsenic, iron, and calcium near Valley Camp Limited were attributed to dust emissions from that source. High concentrations of aluminum, arsenic, and iron and moderately elevated levels of calcium at site 12 were ascribed to blowing fly ash from Ontario Hydro's ash disposal area adjacent to the sampling station. No abnormal quantities of mercury were detected here or at other sites in the sampling area. Concentrations of all parameters were acceptable in the adjacent commercial-residential area of Thunder Bay.

SNOW SAMPLING

Duplicate samples of snow were collected on January 22, 1979, from 12 sites near the Thunder Bay Terminals Limited coal piles (Figure 3), and from two control locations remote from the

source. Core samples of the complete snow profile were obtained with a clean, plastic, hollow cylinder, 10 cm wide and 100 cm long, and open at both ends. To obtain a sample, the cylinder was inserted into the snow to ground level and the snow manually cleared from around one side of the cylinder. The cylinder was then lifted about 5 to 10 cm off the ground and a clean, plastic shovel inserted under its base. The cylinder was raised from the ground and the collected snow transferred to clean, heavy-gauge polyethylene bags for retention in unmelted condition until ready for processing. The number of cores obtained from each site was recorded, as well as the total depth of snow, depth of fresh snow, and the kind and amount of visible surface and subsurface contaminants. Just prior to melting, sample material was transferred to clean, polyethylene bags in the laboratory. The snow-filled bags were sealed, placed in clean, plastic pails (pre-rinsed with distilled water) and melted at normal indoor temperatures. After samples had melted, meltwater was shaken in the bags to ensure uniform distribution of particulate matter. The contents of each bag were poured into a graduated 4-litre beaker and the meltwater volume recorded to the nearest 100 ml (millilitres). The sample was then poured into one-litre nalgene or glass bottles, preservative was added if required, and the sample was submitted for analysis of aluminum, arsenic, calcium, iron, mercury, sodium, sulphate, suspended solids, conductivity and pH at the Ministry's Thunder Bay Laboratory. Carbon analysis was performed at the Ministry's Toronto Laboratory.

Analytical results from the survey are summarized in Table 4. Levels of aluminum, iron, conductivity, suspended solids, total organic carbon and pH were much higher near the Thunder Bay Terminals coal piles than those at the control sites. Elevated readings for all parameters, except those at site 12, were restricted to the immediate vicinity of the coal storage area and decreased rapidly with increasing distance from the coal piles. The distribution pattern for total organic carbon, shown in Figure 4, was similar to that for aluminum, iron,

conductivity, suspended solids, and pH. At station 12, near Ontario Hydro's ash disposal area, aluminum, suspended solids, total organic carbon and iron concentrations were moderately elevated. Deposits of black particulate matter were conspicuous in snow at sites 5 and 6, where contaminant levels were highest. Aluminum, iron and carbon concentrations in snow at these two locations were much higher in 1979 than in 1976, before the terminal project was in operation. No abnormal quantities of arsenic, calcium, mercury, sodium or sulphate were detected.

Linear correlation coefficients of 0.96 and 0.99 were computed between aluminum and total carbon and between suspended solids and total carbon, respectively. These relationships show that the suspended solids were composed almost entirely of carbon and that all the aluminum was associated with the carbon.

AIR QUALITY MONITORING

DUSTFALL

Dustfall, comprising particulate matter which settles out from the air by gravity, was measured at the sites shown in Figure 5. Eight of the 10 sites belonged to a network operated by V. B. Cook Company Limited, project managers for Thunder Bay Terminals Limited. Site 10 (McKellar Hospital) and site 9 (Kam Boating Club) were part of the Ministry of the Environment air quality monitoring network for Thunder Bay. A description of the dustfall measurement method appears in the Thunder Bay Terminals report for 1977 (4).

Dustfall levels for 1979 are given in Table 5. Except for one month at one site (November, Kam Boating Club), monthly and average annual dustfall complied with Ontario objectives at all locations except those on Ontario Hydro property. At sites 4 to 8, near coal piles at Ontario Hydro's generating station on Mission Island, very high dustfall was recorded from late spring to the fall, and, except for site 8, the annual averages were all

above the Ontario air quality objective. Dustfall levels at station 5 and 6 varied substantially from month to month, with a high of 367.2 g/m^2 (grams of dustfall per square metre of ground) in June and low of 1.2 g/m^2 in January. Elevated dustfall readings were attributed principally to major construction activities at the generating station. The generally low dustfall recorded at the Kam Boating Club, about 600 m from the power plant, indicates that the high fallout loadings on Ontario Hydro property were very localized. A comparison between average dustfall from 1976 to 1979 (Table 6) shows that there was no increase in dustfall in the vicinity of Thunder Bay Terminals and the adjacent commercial-residential part of the City following the commissioning of the new coal-handling facility in June, 1978.

SUSPENDED PARTICULATE MATTER

Suspended particulate matter, comprising dust particles of small size, was measured every sixth day with a high-volume air sampler. Details of the sampling method are given in the 1977 Thunder Bay Terminals report (4).

The 1979 data is summarized in Table 7 for three Thunder Bay Terminals sites (sites 1-3) and the Ministry of the Environment site (site 10). Total suspended particulate exceeded the Ontario objective of 120 $\mu g/m^3$ (micrograms of particulate matter per cubic metre of air) on two of 61 sampling dates at Shell oil, once at the sewage plant and at Thunder Bay Terminals, and four times at McKellar Hospital. The provincial objective of 60 $\mu g/m^3$, annual geometric mean, was met at all sites in 1979, as it was in previous sampling years. A 4-year summary of annual average suspended particulate concentrations, in Table 8, shows no evidence of significant change between the pre-operational and post-operational situation in the vicinity of Thunder Bay Terminals Limited.

ACKNOWLEDGEMENT

The Ministry of the Environment is grateful to V. B. Cook Company Limited, project managers for Thunder Bay Terminals Limited, for providing dustfall and suspended particulate data.

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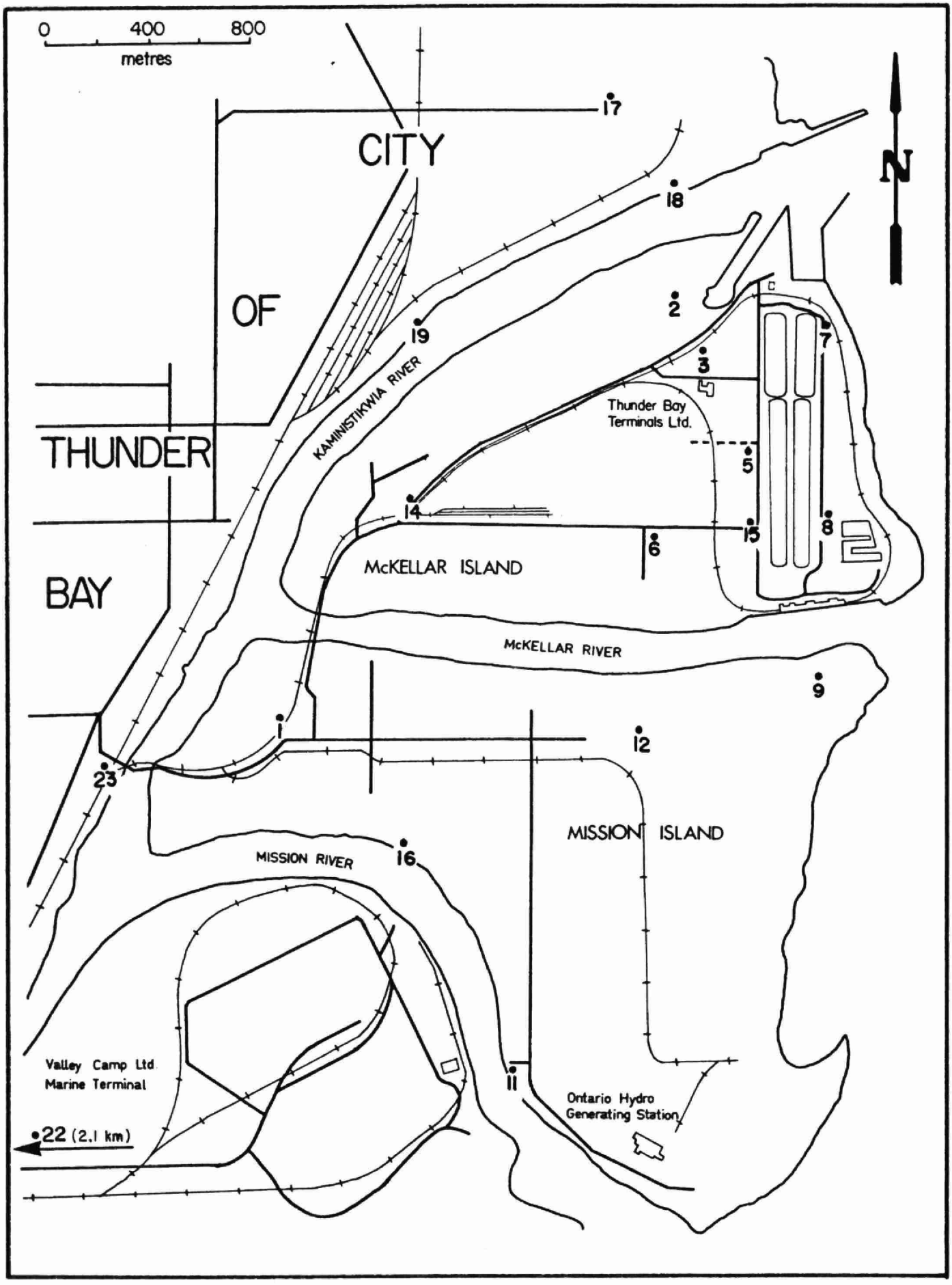

Figure 1. Vegetation, soil (0-10 cm) sampling and moss bag exposure sites, 1979.

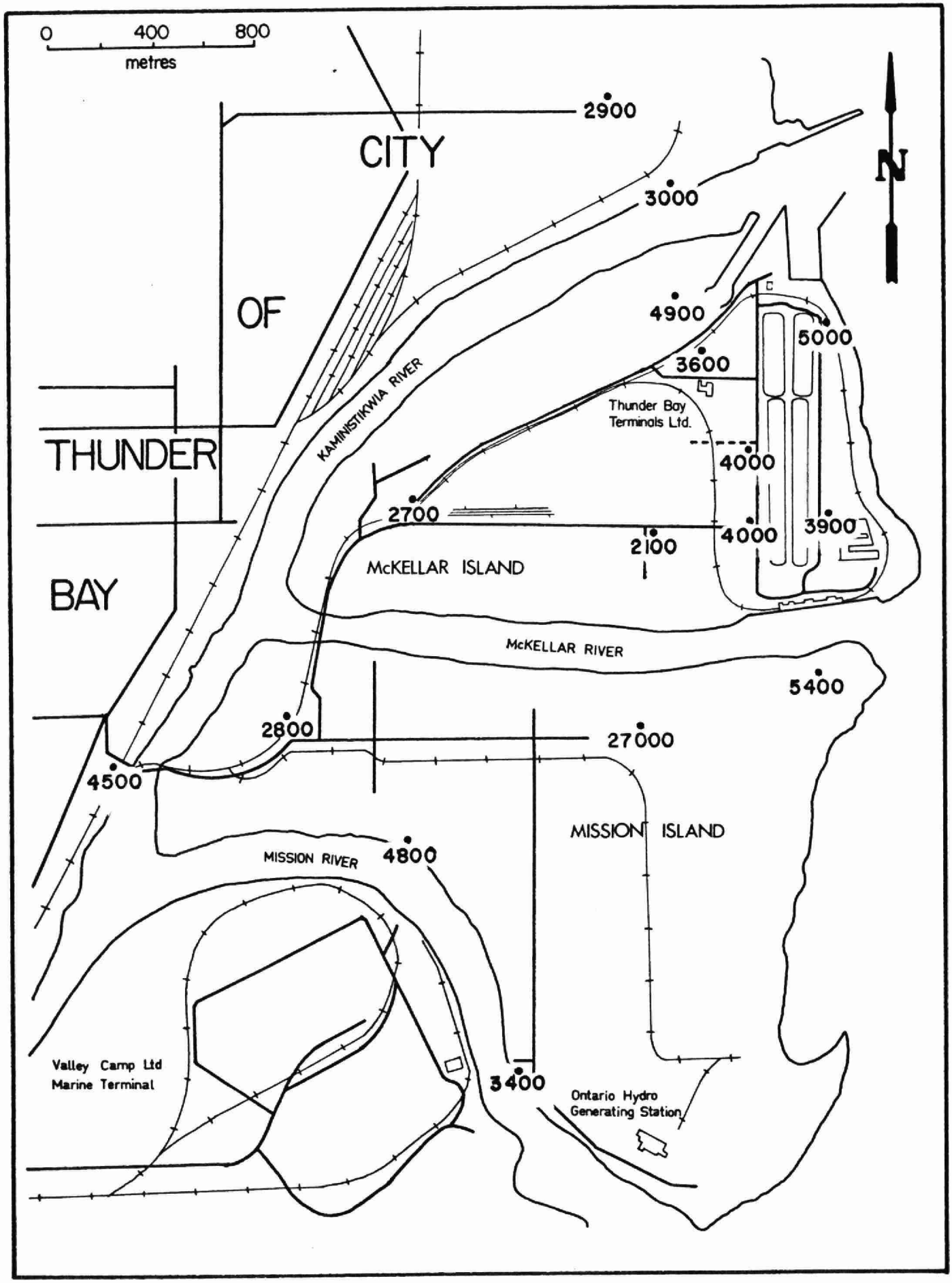

Figure 2. Levels of iron (µg/g, dry weight) in moss, 1979.

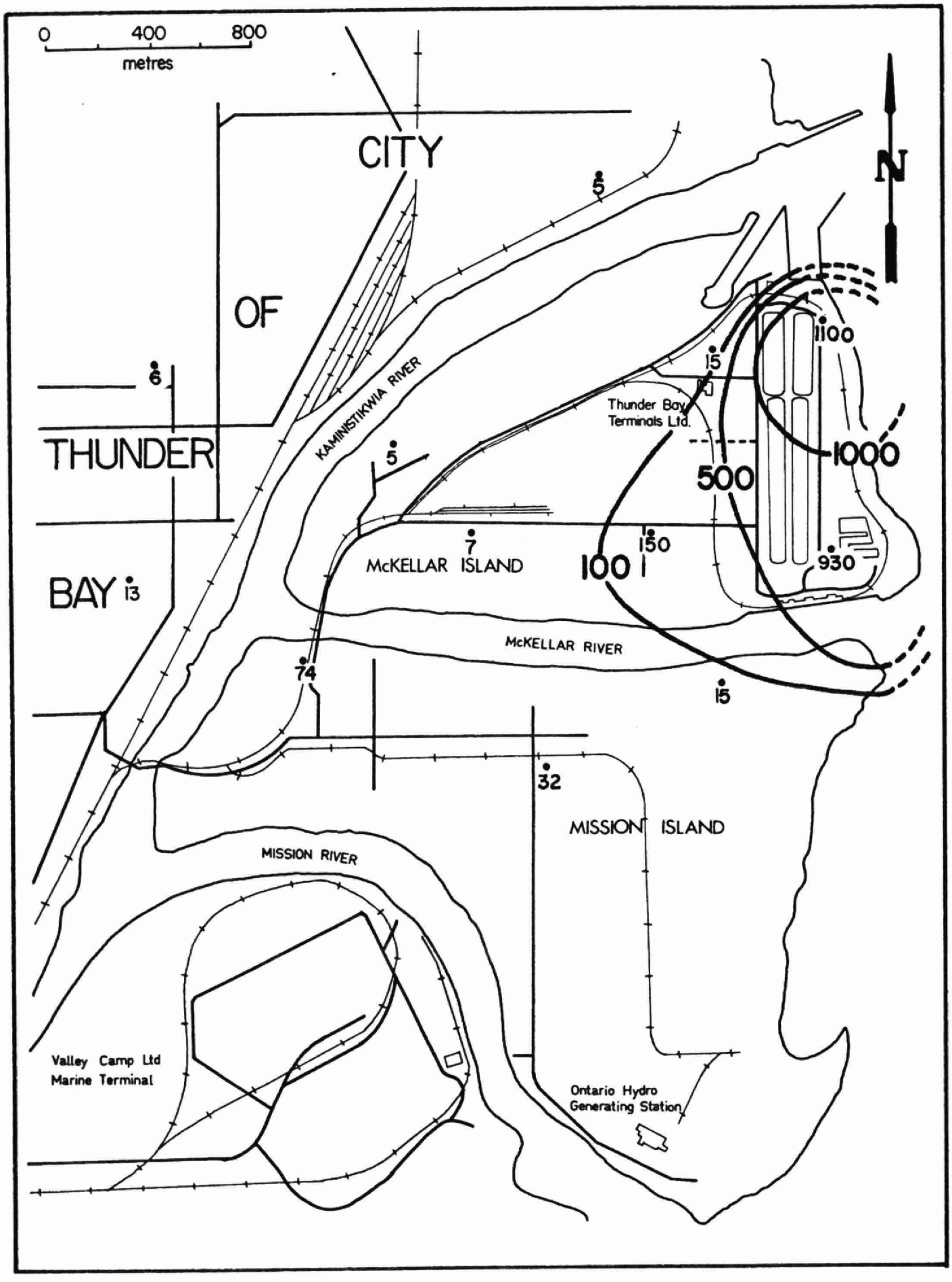

Figure 4. Levels of total organic carbon (mg/l) in snow, 1979.

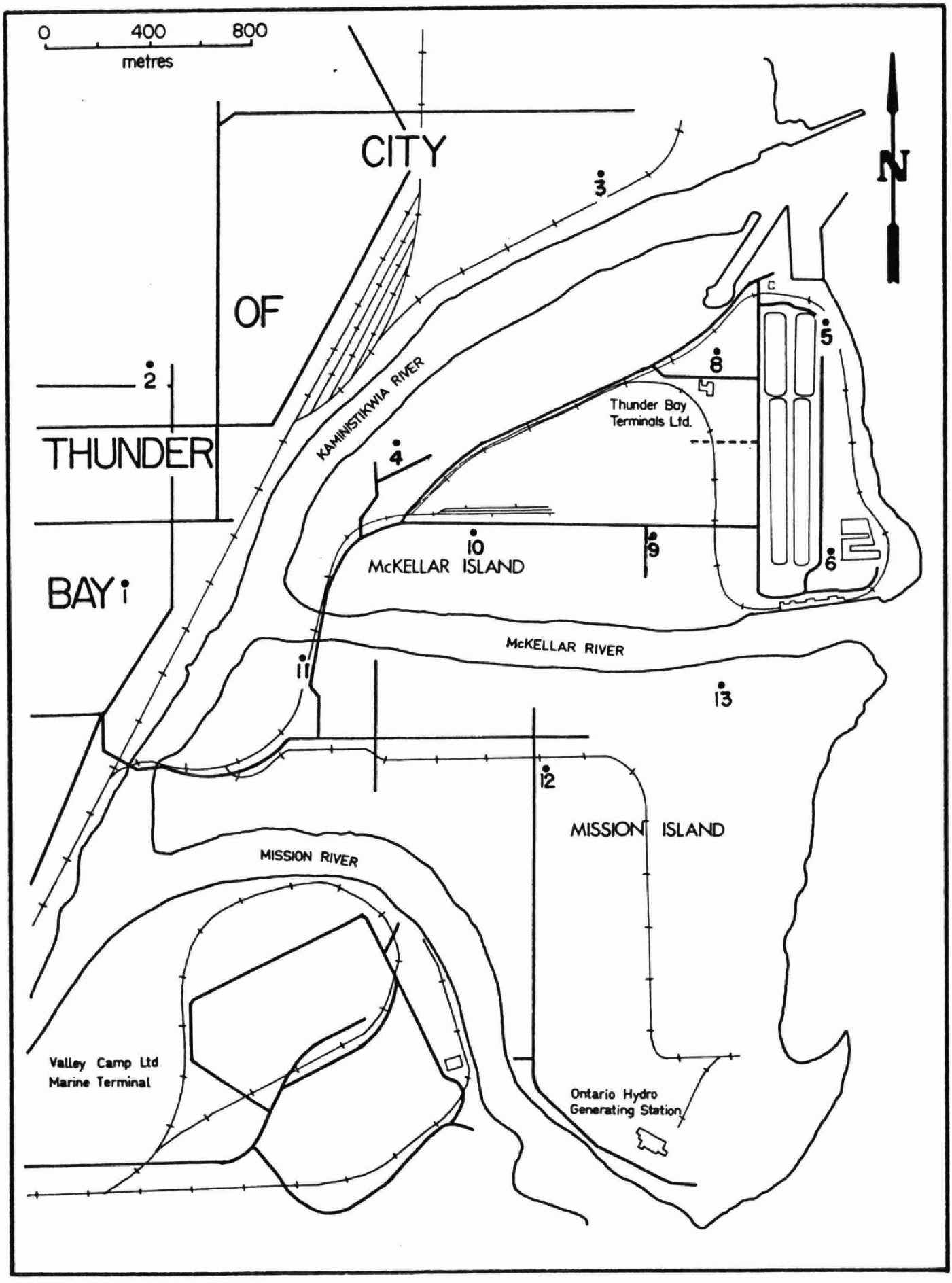

Figure 3. Snow sampling sites, January 22, 1979.

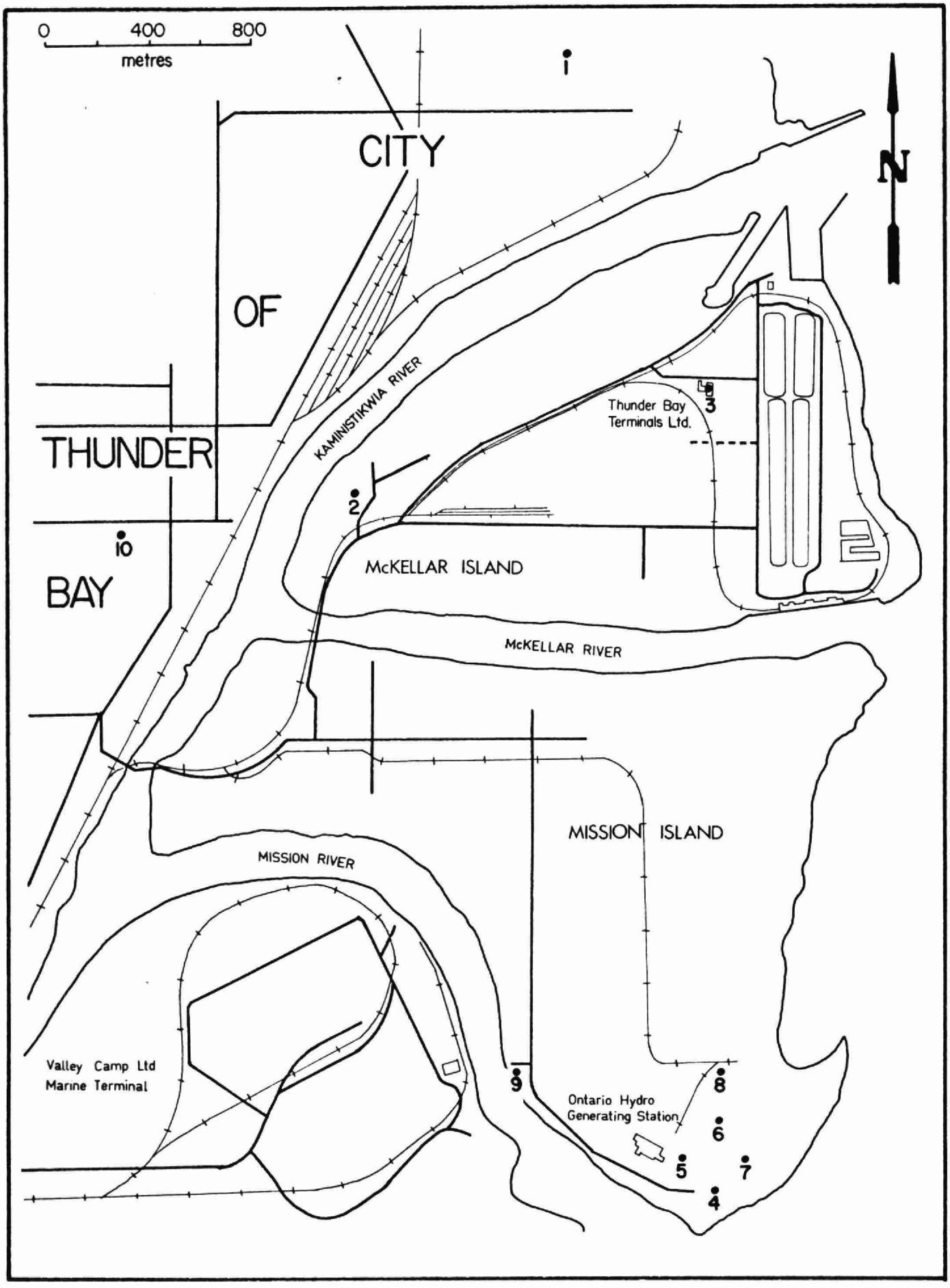

Figure 5. Air quality monitoring sites, 1979.

TABLE 1. Average levels of aluminum, arsenic, iron and mercury (µg/g, dry weight) in unwashed trembling aspen or balsam poplar foliage collected in the vicinity of Thunder Bay Terminals Ltd., July 10, 1979.

Site	Foliage sampled	Aluminum	Arsenic	Iron	Mercury
1	Trembling aspen	120	<1	330	0.03
2	Balsam poplar	440	<1	1700	0.03
5	Trembling aspen	130	<1	440	0.03
6	" "	100	<1	400	0.02
7	Balsam poplar	230	<1	750	0.03
8	" "	130	<1	500	0.03
9	Trembling aspen	190	<1	530	0.02
11	" "	530	1	1500	0.03
12	" "	340	1	910	0.03
14	" "	120	<1	470	0.03
15	" "	490	<1	1100	0.03
16	" "	100	<1	1400	0.03
17	" "	41	<1	260	0.04
18	" "	110	<1	370	0.04
22	" "	110	<1	440	0.04
23	" "	110	<1	670	0.06
Control	Trembling aspen	67	<1	200	0.01
Control	Balsam poplar	1100	<1	2400	0.01
Normal background		<400	<8	<800	<0.10

TABLE 2. Average levels of arsenic and mercury (µg/g, dry weight) in soil (0-10 cm) collected in the vincinity of Thunder Bay Terminals Ltd., May 22-23, 1979.

Site	Arsenic	Mercury
1	7	0.06
2	3	0.05
3	2	0.01
5	5	0.07
6	4	0.07
7	3	0.03
8	2	0.02
9	3	0.10
11	5	0.06
12	5	0.04
14	4	0.06
15	35	0.10
16	7	0.14
17	6	0.07
18	6	0.06
19	6	0.15
22	11	0.09
23	7	0.07
Controls	4	0.04
Normal background	<25	<0.30

TABLE 3. Levels of aluminum, arsenic, calcium, iron and mercury (µg/g, dry weight) in Sphagnum moss exposed from May 22 to July 10, 1979.

Station	Aluminum	Arsenic	Calcium	Iron	Mercury
1	1300	1.2	5700	2800	0.10
2	3100	2.0	6300	4900	0.08
3	2000	1.9	6000	3600	0.10
5	2800	1.9	5200	4000	0.13
6	1700	<1.0	4500	2100	0.20
7	3000	2.1	13000	5000	0.12
8	2600	1.2	7100	3900	0.16
9	3200	1.8	6900	5400	0.12
11	1600	2.6	5100	3400	0.14
12	11000	31.0	10000	27000	0.15
14	1900	<1.0	3700	2700	0.15
15	2400	1.7	7600	4000	0.10
16	2000	4.5	4000	4800	0.15
17	2100	1.9	4300	2900	0.10
18	2000	1.1	5600	3000	0.13
19	--	--	--	--	--
22	1300	<1.0	4800	2000	0.10
23	1700	1.8	6500	4500	0.17
Exposed controls	1600	1.3	5600	2000	0.12
Unexposed controls	1300	<1.0	3700	1700	0.14

TABLE 4. Levels of aluminum, arsenic, calcium, total organic carbon, iron, mercury, sodium, sulphate, suspended solids, conductivity, and pH in snow collected in the vicinity of Thunder Bay Terminals Limited, Thunder Bay on January 22, 1979.

Station	Aluminum (mg/l)	Arsenic (µg/l)	Calcium (mg/l)	Total organic carbon (mg/l)	Iron (mg/l)	Mercury (µg/l)	Sodium (mg/l)	Sulphate (mg/l)	Suspended solids (mg/l)	Conductivity (µmhos/cm)	pH
1	0.6	10	< 1	13	21	< 0.05	3	3	50	30	6.4
2	0.5	< 4	< 1	6	5	< 0.05	3	3	42	30	4.8
3	< 0.5	< 4	< 1	5	< 1	< 0.05	1	2	8	19	4.7
4	< 0.5	< 4	< 1	5	1	< 0.05	< 1	2	15	16	4.7
5	44.5	20	8	1100	36	0.08	< 1	5	2460	48	8.5
6	37.5	20	7	930	26	0.06	< 1	8	1710	50	7.9
8	2.6	< 4	2	15	10	< 0.05	2	3	100	44	6.3
9	3.4	10	< 1	150	3	< 0.05	< 1	4	200	24	6.4
10	< 0.5	< 4	< 1	7	1	< 0.05	< 1	2	15	17	4.6
11	0.6	26	< 1	74	46	< 0.05	4	2	225	47	4.6
12	2.6	6	2	32	10	< 0.05	5	2	140	42	5.8
13	< 0.5	< 4	< 1	15	1	< 0.05	1	2	32	16	4.8
Controls	< 0.5	< 4	< 1	3	< 1	< 0.05	< 1	1	7	15	4.5
Guidelines	1.0	10	5		1	0.50	5	5			

TABLE 5. Dustfall (g/m^3/30 days) in the vicinity of Thunder Bay Terminals and Ontario Hydro, 1979.

Site	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1	Sewage Plant	0.3	1.0	3.1	3.9	4.4	5.0	4.3	3.5	3.2	1.1	2.1	1.5	2.8
2	Shell Oil Terminal	0.7	0.7	6.8	3.6	5.5	6.7	5.7	4.6	4.0	2.3	1.0	2.9	3.7
3	Thunder Bay Terminals	0.8	1.1	4.0	4.2	3.4	4.6	3.6	3.1	2.9	1.6	0.6	2.3	2.7
4	Ontario Hydro (SE)	0.7	1.3	3.8	4.2	19.0[a]	14.7	9.1	5.3	4.3	2.7	3.5	2.1	5.9
5	Ontario Hydro (SW)	2.3	2.1	17.6	2.6	2.8	12.3	14.0	16.9	275.9	7.3	2.1	3.3	29.9
6	Ontario Hydro (NW)	1.2	1.5	3.6	8.7	14.7	367.2	15.0	17.6	10.1	4.0	6.0	3.9	37.8
7	Ontario Hydro (NE)	1.6	1.3	4.3	-	10.5	23.0	21.8	36.8	13.5	8.7	10.7	5.0	12.5
8	Ontario Hydro (N)	2.1	1.5	3.6	3.1	7.5	6.9	14.3	3.7	4.6	1.0	1.8	3.0	4.4
9	Kam Boating Club	3.8	1.5	2.4	5.5	3.9	6.7	6.5	3.2	4.4	1.6	8.9	1.5	4.2
10	McKellar Hospital	2.4	1.0	2.7	6.1	6.0	6.1	4.6	3.6	4.5	2.7	3.8	2.0	3.8

[a]Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 6. Average dustfall (g/m^2/30 days) in the vicinity of Thunder Bay Terminals Limited and Ontario Hydro, 1976-1979.

Site	Location	1976	1977	1978	1979
1	Sewage treatment plant	3.2	4.4	3.2	2.8
2	Shell Oil plant	4.2	8.4[a]	5.1	3.7
3	Thunder Bay Terminals	4.2	4.2	2.7	2.7
4	Ontario Hydro (SE)	4.2	11.5	7.4	5.9
5	Ontario Hydro (SW)	11.2	24.1	15.5	29.9
6	Ontario Hydro (NW)	5.2	34.8	9.6	37.8
7	Ontario Hydro (NE)	13.3	14.6	13.0	12.5
8	Ontario Hydro (N)	7.0	5.2	5.6	4.4
9	Kam Boating Club	5.6	4.6	4.3	4.2
10	McKellar Hospital	3.5	5.0	3.8	3.8

[a]Values exceeding maximum acceptable levels of 4.6 are underlined.

TABLE 7. Concentrations of total suspended particulate matter ($\mu g/m^3$) in the vicinity of Thunder Bay Terminals Limited, 1979.

Date	Sampling site 1	2	3	10	Date	Sampling site 1	2	3	10
Jan 3	16	32	24	--	Jul 2	28	38	18	45
9	16	22	27	19	8	46	47	90	75
15	32	39	48	34	14	94	137	79	88
21	22	27	26	15	20	54	29	89	76
27	9	16	15	--	26	47	87	71	49
Feb 2	53	60	66	--	Aug 1	54	86	57	230
8	22	23	26	--	7	54	98	44	46
14	12	14	15	20	13	24	37	29	29
20	45	46	51	87	19	38	69	40	51
26	34	37	32	44	25	14	22	30	26
					31	26	36	27	44
Mar 4	18	32	29	18	Sep 6	32	45	39	52
10	33	31	38	22	12	33	31	22	45
16	68	64	74	76	18	39	55	34	50
22	25	29	29	47	24	53	84	47	52
28	23	24	25	45	30	33	41	28	47
Apr 3	37	65	45	75	Oct 6	19	29	27	--
9	43	48	51	53	12	26	34	20	39
15	18	40	37	52	18	58	76	23	72
21	22	20	23	78	24	145	11	18	56
27	32	52	53	111	30	25	35	5	80
May 3	32	68	36	65	Nov 5	29	46	13	31
9	13	47	27	65	11	31	33	31	46
15	27	50	30	96	17	41	25	26	50
21	21	30	35	58	23	18	29	20	41
27	51	59	56	128[a]	29	11	33	22	26
Jun 2	52	77	57	63	Dec 5	18	30	24	37
8	76	104	67	156	11	16	20	21	32
14	96	144	162	146	17	27	28	35	43
20	39	54	69	55 (Jun 22)	23	10	32	15	29
26	56	100	20	--	29	16	21	20	36
				Annual geometric means		30	41	33	51

[a]Values exceeding maximum acceptable level of 120 $\mu g/m^3$ (24-hour average) are underlined.

TABLE 8. Annual geometric means of total suspended particulate matter ($\mu g/m^3$) in the vicinity of Thunder Bay Terminals Limited and Ontario Hydro, 1976-1979.

Site	Location	1976	1977	1978	1979
1	Sewage treatment plant	41	31	27	30
2	Shell Oil plant	61[a]	60	48	41
3	Thunder Bay Terminals	47	33	34	33
10	McKellar Hospital	49	36	44	51

[a]Values exceeding maximum acceptable levels of 60 $\mu g/m^3$ (annual geometric mean) are underlined.